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PROJECT MEMORANDUM

DATE: May 1, 2013

FROM: Claudia Zahorcak, PE – David Evans and Associates, Inc.

TO: South Cooper Mountain Technical Advisory Committee

CC: South Cooper Mountain Project Management Team

SUBJECT: **Storm Water Future Needs**

PROJECT: **South Cooper Mountain Concept and Community Plans**
City of Beaverton #2752-13B

DEA PROJECT NO: APGI0000-0002

Executive Summary

There are no publicly owned storm water conveyance and treatment facilities, other than natural stream channels and road drainage, within the study area. The natural drainage patterns of the study area were reviewed and the three portions of the study area assessed for where new storm water conveyance facilities might be connected to existing systems outside the study area.

As described in the SCM Storm Water Existing Conditions technical memorandum, only 13 percent of the area has good potential for widespread application of infiltration, a key method in the Low Impact Development Approach for storm water management preferred by Clean Water Services, based on analysis of mapped information on soil hydrologic group, depth to groundwater, and slope. For planning purposes, the primary approach for meeting storm water management goals will be detention in the developing areas in order to manage peak runoff rates to avoid downstream impacts. This technical memorandum develops a sizing tool to estimate the area required for detention as a percentage of the subbasin for related post-development impervious area.

Steep slopes and shallow soils in the area contribute to the potential for erosion, which could cause channel cutting and resulting sedimentation in lower stream reaches. A major consideration in laying out storm water conveyance and treatment facilities for the three portions of the study area is the requirement that development not contribute to erosion and that water quality controls be incorporated into the systems. Much of the adjacent served area includes both closed and open conveyances, and preventing erosion both in and downstream of the study area will be important.

The future development of the Urban Reserve Area will need to be carefully managed to minimize stream erosion of the existing channels flowing southwest from the peak of Cooper Mountain to McKernon Creek. Although the North Cooper Mountain area is not currently within the Clean Water Services boundary, as the southern portion of this area is the upland area for the Urban Reserve Area and drains southwest, consideration should be given to applying strict storm water control in this area to minimize stream erosion in the Urban Reserve Area. If further development in the northern portion of the North Cooper Mountain is planned, managed connections to the Clean Water Services Cross Creek, Butternut Creek, and Johnson Creek conveyance systems to the north and northeast will need to be included.

If the eastern portion of the Urban Reserve Area is developed, managed connections to the City of Beaverton's Summer Creek conveyance systems to the east and southeast will need to be included. Storm water management will be required to minimize erosion of the existing stream channels, as well as minimize the impact on the downstream channel of McKernon Creek (for west-flowing areas) and Summer Creek (for east-flowing areas). The portion of SW Kemmer Road, west of SW 175th Avenue, would also drain to the Summer Creek system. The eastern portions of both the Urban Reserve Area and the South Cooper Mountain Annexation Area include the headwaters of Summer Creek. Development in these area will need conveyance systems that connect to the creeks without causing channel erosion within the two areas, as well as not adversely impacting downstream Summer Creek conveyance elements, which alternate from open to closed conveyance channels as the creek flows east. The western two-thirds of the South Cooper Mountain Annexation Area are the headwaters of an unnamed tributary to the Tualatin River. Development in this area will similarly need to be configured to minimize channel erosion within and south of the study area.

The North Cooper Mountain Connections Map and the South Cooper Mountain Annexation Area Connections Map illustrate the likely elements of the existing Clean Water Services and City systems, respectively, that new systems might connect to.

Project Overview

The South Cooper Mountain Concept Plan will establish a vision that serves as a long-term guide for future growth and development of the South Cooper Mountain area. The Concept Planning process provides an opportunity to identify long term needs of the area and proactively address future challenges. This process will recognize the unique needs of the three distinct subareas (North Cooper Mountain, the Urban Reserve Area, and the South Cooper Mountain Annexation Area) while developing a holistic understanding of how the three areas could integrate and grow sustainably. The concept plan area totals 2,290 acres.

Community plans identifying appropriate comprehensive plan and zoning designations that implement the overall vision in the concept plan will be developed for the areas that are currently within the UGB. The South Cooper Mountain Annexation Area Community Plan will designate specific areas for a range of housing types and densities, commercial and civic uses, and parks; preserve natural resources; provide for green infrastructure; and plan for new utilities, streets, trails and paths. The North Cooper Mountain Community Plan will reflect the needs of current residents in this already developed area, and result in an appropriate plan for the area's future. Planning for the Urban Reserve Area will guide how best to protect natural areas and Cooper Mountain Nature Park, where future urban development may occur, and where connecting streets, water lines, and other utilities should be located. A Finance Plan will identify realistic strategies for paying for infrastructure to serve the area.

Introduction

This memo provides a summary of future needs for storm water management within and adjacent to the South Cooper Mountain (SCM) study area. See the SCM Existing Storm Water Facilities memorandum for a map of existing streets and natural drainage. There are three (3) sub-areas defined in this study. They are "North Cooper Mountain (NCM)," "Urban Reserve Area (URA)," and "South Cooper Mountain Annexation Area (SCMAA)" as shown on the map, Existing Storm Conveyance and Treatment.

At the current time, there are no storm water conveyance or treatment facilities managed by either the City of Beaverton (City) or Clean Water Services (CWS) within the SCM study area. The only facilities are culverts and drainage ditches associated with roads and culverts conveying creeks under county roads. The Existing Storm Conveyance and Treatment map illustrates the existing closed conveyances that serve the areas north and east of the study area, that might receive flow from the fringes of the SCM area.

Future Needs for Conveyance and Treatment

Washington County (County) maintains county roads that run along the perimeter of the study area, such as SW Scholls Ferry Road, SW Tile Flat Road, SW Grabhorn Road, SW Kemmer Road and SW 175th Avenue. McKernon Creek and unnamed tributaries to the Tualatin River, Cross Creek, and Butternut Creek are crossed by these roads. The County would be responsible for maintaining any culverts to minimize upstream flooding and maintain its identified level of service.

Developing areas not served by CWS fall under the County rural area guidelines. Once they are served by CWS, new construction within the areas will need to follow their prevailing Design and Construction Standards (DCS), which call for water quality controls.

CWS maintains storm water systems in the unincorporated urbanized areas of the County within their boundary. In considering the future needs, CWS' service area does not include rural areas, and their policy (which could change in the future) is only to annex new areas after they have been annexed by a city.

CWS will be receiving soon (anticipated sometime in 2013) its renewed National Pollution Discharge Elimination System (NPDES) permit for its Municipal Separate Storm Sewer Systems (MS4). In addition to requirements for controlling pollution from urban storm water, the permit is also likely to require a program that will eventually place controls on the quantity of flows released to area streams in order to minimize hydrographic modification, and CWS is currently updating their DCS in anticipation of this requirement. The primary means of control will be new standards that will aim for post-development runoff peak flows (for a stated range of storms) to match pre-development peak flows. While the means for this is often left to the property owner, CWS will review the proposed development to ensure designs conform to their DCS.

The City maintains open and closed conveyance facilities (i.e., ditches or creeks, and storm sewers, respectively) and water quality facilities (i.e., storm ponds) adjacent to the eastern and southeastern portions of the study area. The City owns and maintains the conveyance facilities located within city limits, and will maintain new facilities when constructed in the SCMAA. Most of these adjacent closed conveyance facilities are small diameter, short storm sewers that alternate with open conveyance (ditches or creeks). Only small areas of the perimeter of the study area would drain to these existing facilities; it is likely that these areas will also need to include storm water quality and quantity controls to minimize a significant impact on these downstream systems. It may also be necessary for capital improvements to segments of the existing downstream storm sewers in order to accommodate flows from the SCM; however, it can also be anticipated that CWS' development standards would result in a limited impact on these systems.

The majority of the three portions of the SCMAA study area drain south, towards the Tualatin River via (east to west): Summer Creek, an unnamed tributary, and McKernon Creek. Summer Creek flows through urbanized and highly developed Beaverton. The future development of the SCMAA area that flows east towards Summer Creek will need to carefully manage storm water to minimize downstream impacts. The majority of the SCMAA will flow to the unnamed tributary which crosses SW Scholls Ferry Rd between SW 175th Avenue and SW Tile Flat Road. This tributary continues to flow through the River Terrace area of Tigard, for which a Concept Plan is being developed. McKernon Creek, on the other hand, flows west through area outside the UGB and is completely rural. The future development of the URA will need to be carefully managed to minimize stream erosion of the existing channels flowing southwest from the peak of Cooper Mountain to McKernon Creek.

The following discussion highlights the potential needs for storm water conveyance systems by subarea.

North Cooper Mountain

The NCM area is not likely to be served by CWS unless property owners request annexation into the City of Beaverton, or CWS' policy changes. Even if the subarea were annexed into the District's service area, the current property owners would need to petition CWS to provide service, and would likely need to form a Local Improvement District (LID). A trigger for CWS providing storm water service would also be if an LID was formed to provide sanitary sewage collection (the area is currently served by individual septic systems).

The Storm Water Connections--NCM map illustrates the few locations where drainage from this area could be connected to existing storm sewers. A major drainage divide runs west to east through the middle of this area. SW Nancy Street, SW Miller Hill Road, SW Eagle Crest Terrace, SW Heightsview Court, and a portion of SW Heightsview Drive and SW 190th Avenue drain north towards SW Gassner Road and then north to subbasins that drain to Cross Creek and Butternut Creek. While it is possible that SW Gassner Road diverts portions of this flow differently, it can be assumed based on topography that storm water generated in the northern half of the NCM area is currently finding its way to the open conveyance system or to the closed pipes included in the table below.

The developed area (SW Wolds Drive) west of SW Grabhorn road also is assumed to drain to a tributary of Cross Creek, based on topography; there are no storm water facilities to intercept this flow. The undeveloped area in the northeast section of NCM (east of SW 190th Avenue and north of SW Kemmer Road) drains to Johnson Creek South (Wash Co); there are no existing storm water facilities to intercept this flow.

The following closed conveyance storm sewers would be likely connection points were the northern and eastern portions of the NCM area to be further developed and a storm water conveyance system installed.

UP-STREAM FACILITY ID	DOWN-STREAM FACILITY ID	LOCATION	MATERIAL	DIA-METER, inches	UPSTREAM ELEVATION	DOWN-STREAM ELEVATION	SLOPE	LENGTH, feet
107787	107786	SW 191st Avenue	CSP	12	663.18	617.52	0.1600	275
116802	116801	SW 191st Avenue	CSP	12	635.82	616.25	0.1012	191
116803	116802	SW Winslow Drive	CSP	12	642.45	635.62	0.0623	111
170410	170409	W of SW 195th Place	PVC	12	641.84	629.53	0.0985	125
277539	277538	SW Hayden Drive w of SW 187th Ave	PVC	12	656.07	649.95	0.0720	85
277562	277561	SW Hayden Drive e of SW 187th Ave	PVC	12	658.01	656.84	0.0079	148
283637	283634	SW Jeremy Street	PVC	12	731.22	731.05	0.0050	34
284789	284788	SW Valiant Drive	PVC	12	611.14	610.29	0.0090	94
284829	284824	SW 200th Terrace	DIP	12	613.20	611.35	0.0410	40

The remainder of the NCM area drains south towards the URA and eventually to McKernon Creek. As these areas are the most upland areas of the McKernon Creek tributary system, care will be needed to ensure these NCM flows are properly managed to minimize erosion.

Urban Reserve Area

Assuming no change in the current CWS policy, even after the URA enters the Urban Growth Boundary (UBG), it would similarly not be served by CWS until urban development occurs after properties in the subarea are annexed by the City of Beaverton, and comprehensive and zoning designations have been adopted.

Storm water management will be required to minimize erosion of the existing stream channels, as well as minimize the impact on the downstream channel of McKernon Creek (for west-flowing areas) and Summer Creek (for east-flowing areas). The eastern portion of the URA includes the headwaters of a tributary to Summer Creek. Development in this area will need a conveyance system that connects to the creek without causing channel erosion, as well as not adversely impacting downstream City of Beaverton conveyance elements, which alternate from open to closed conveyance as the creek flows east. Due to the high relief and numerous channels, vegetation management (protection and potentially restoration of riparian corridors on the multiple tributaries) will be a principal means of minimizing channel erosion. Any development in the upland areas will need to have storm water controls in place to minimize downslope erosion that could result in erosion of existing (or formation of new) channels and sediment contribution to the tributary.

South Cooper Mountain Annexation Area

CWS requires property owners to petition to be added into CWS' service area prior to development. Urban development will not be authorized in this subarea until the concept plan is completed, and a community plan with appropriate comprehensive plan and zoning designations are adopted. Prior to approval of development plans, properties will be required to annex into CWS, automatically triggering the requirement that all development follow CWS' DCS.

The western two-thirds of the SCMAA drain south to an unnamed tributary to the Tualatin River. Before entering the Tualatin River, this tributary joins with the unnamed stream draining the West Bull Mountain area (River Terrace) north of West Bull Mountain Road. These two areas are now within the UGB, are adjacent to populated areas (Beaverton and Tigard, respectively), and will likely be developing about the same time. Both areas will need to be developed with sufficient storm water controls to minimize erosion of the downstream reaches of this tributary, and should be coordinated.

The eastern portion of the SCMAA includes the headwaters of a tributary to Summer Creek. Development in this area will need a conveyance system that connects to the creek without causing channel erosion, as well as not adversely impacting downstream City of Beaverton conveyance elements, which alternate from open to closed conveyance channels as the creek flows east. The Storm Water Connections—SCMAA map illustrates the potential connections points for the eastern third of the SCMAA (east of SW 175th Avenue). The City will need to plan for the conveyance of this flow downstream past SW Scholls Ferry Road. Managing flow quantity from the SCMAA will be a key element of the development north of SW Scholls Ferry Road to minimize adverse impact on the road crossing and the downstream channel.

UPSTREAM FACILITY ID	DOWNSTREAM FACILITY ID	LOCATION	MATERIAL	DIAMETER, inches	LENGTH, feet
SQ0810	SQ0809	SW Loon		10	105
SQ1506	SQ1505	SW Roshak at SW Barrows	CP-concrete	24	29

Future Storm Water Quality and Quantity Controls

Development impacts storm water in two ways: 1) by increasing impervious area, resulting in greater proportions of rainfall becoming runoff (quantity); and 2) by affecting the mix of pollutants that can be borne by that runoff and carried to downstream waters of the U.S (quality). The goal of storm water management in the South Cooper Mountain area will be to proactively incorporate features into the planning that will meet long-term goals of the City of Beaverton and CWS. These goals include meeting the requirements of the Clean Water Act, as laid out in CWS' current and future MS4 permits; the permit addresses requirements to manage storm water quality. Another goal, which is consistent with national policy, is to reduction stream channel erosion caused by increasing storm water quantity.

There are three approaches to complying with both these goals:

1. Avoidance—preserve direct connection to soils by preserving pervious areas, and enhance vegetative interception of rain and soil uptake (e.g., minimize impervious area and maximize natural areas)
2. Infiltration--direct flow from impervious areas to pervious areas where further soil and vegetative interaction can take place (e.g., local infiltration systems)
3. Detention—capture a portion or all of the runoff that doesn't infiltrate and reduce the flow rate or volume that is still discharged to the downstream channel or sewer system.

To varying degrees, each of these approaches assist with meeting both quantity and quality goals. To implement these three approaches at the site and neighborhood development level, CWS recommends the application of Low Impact Development Approach (LIDA) methodologies to reduce peak runoff rates and improve storm water quality. They have provided guidance in their Low Impact Development Approaches Handbook (July 2009). The five objectives of LIDA are to:

1. Conserve Existing Resources
2. Minimize Disturbance
3. Minimize Soil Compaction
4. Minimize Imperviousness
5. Direct Runoff from Impervious Areas onto Pervious Areas

Methods included in the manual are identified, and guidance for their selection summarized, in Table 1 from the manual.

Table 1: LIDA Selection for Site Conditions

	Green Roof	Porous Pavement	Flow-through Planter	Infiltration Planter/ Rain Garden	Vegetated Filter Strip	LIDA Swale
Reduce imperviousness	✓	✓				
Infiltrate		✓		✓	✓	✓
Detention/ flow control		✓		✓		
Provide Habitat			✓	✓	✓	✓
Near Vegetated Corridor			✓	✓	✓	✓
Private property	✓	✓	✓	✓	✓	✓
Private street		✓	✓	✓	✓	✓
Public Street/ROW*			✓		✓	✓
On or next to building	✓		✓			
Parking lot		✓	✓	✓	✓	✓
Landscaped area			✓	✓	✓	✓
Steep slope	✓		✓			
Soils with low infiltration rate	✓	✓	✓		✓	✓
High GW table	✓		✓		✓	✓
Contaminated soils	✓		✓			

* Check with local juristiction about use in ROW

Source: Clean Water Services, Low Impact Development Approaches Handbook, July 2009.

As presented in the SCM Storm Water Existing Conditions technical memorandum, the application of infiltration methodologies to reduce peak runoff rates and improve storm water quality may be limited in the SCM study area, due to the slopes, soil types, and depth to groundwater. Only 13 percent of the study area appears to be moderately suitable for infiltration. Although site specific assessments should be performed prior to development, this finding sets the general approach for addressing the future needs of the study area as it develops. While infiltration should be examined at the site level, for planning purposes the principal broad-scale tool in the SCM development will likely be local storm

water detention of small storms with the aim of matching pre-development flow patterns, as described below.

It should be noted that the current CWS MS4 permit will be reissued sometime in 2013 or 2014 and the new permit can be expected to require formal steps to achieve national storm water goals by 1) addressing receiving stream water quality through reduction in storm water pollutants carried in runoff, and 2) addressing stream health through maintaining the existing flow regime. The latter goal means identifying current runoff rates and then, as development occurs, preventing a significant rise in the peak rate and duration of peaks) of runoff contributed to open channels. Managing the runoff quantity for channel forming flows (generally considered to be the 2-year return frequency storm or smaller) is a different concern than managing flows to prevent flooding of adjacent properties (typical storm water conveyance systems are designed to convey the 10-year return frequency storm). While the requirement to adjust the flow regime to mimic natural conditions may be phased in over multiple permit cycles, for purposes of planning in the SCM area, this requirement is assumed to apply.

By managing a range of smaller peak storm water flows generated through development (through increasing impervious area) to be approximately the same as a pre-development condition (forested or grass) the expectation is that stream health will be maintained. A healthy stream is considered one whose channel will not suffer hydromodification, a term that reflects the changes in bank stability, erosion, higher turbidities, and other impacts that have been seen to occur in developed areas without storm water controls. While there are other indicators of stream health (including habitat, substrate, and riparian health), hydromodification is the element which will be addressed in this analysis. Riparian health will be addressed through CWS' Vegetated Corridor requirements, discussed in the SCM Natural Resources report.

To provide the SCM concept planning team a general set of guidelines to plan stormwater management as the area develops, we reviewed the relationship between a hydrologic subbasin's percent imperviousness and the percentage of the subbasin that needs to be devoted to detention. This relationship is important, as it factors into the calculation of net developable acres by subbasin.

The Impact of Increasing Imperviousness Chart displays a number of key items relative to storm management. The solid blue and red lines show the relationship of a subbasin's flow response as it progresses from pre-developed to fully developed sites (using percent impervious area as the indication and grass as the pervious area when developed). The predicted peak runoff rate for the 1-year and 2-year flow rates are shown (blue and red lines, respectively, read from the left y-axis). These rates are usually near the channel-forming flow rates, so they provide reasonable guidance for stream protection flows. The curves represent runoff from a 10-acre basin with HSG C soils. The curves begins at fully-forested, then grass, then progress in percent impervious area up to 100 percent. The solid curves represent the outcome of development with no controls; this would result in hydrographic modification.

Setting target flows for stream protection requires a site-specific analysis of current geomorphology conditions in the target streams. Similar analyses in basin plans in the Puget Sound region have found that basin development relating of ten percent impervious area, 15 to 25 percent grass, and 65 to 75 percent forest have a basin hydrologic response that relates to the target flow regime for stream protection in those streams. The flow rate for the 10 percent impervious, 15 percent grass, and 75 percent forest is shown in the blue triangle and red square. This can be generally supported by analysis of basin imperviousness when compared to the Benthic Index of Biotic Integrity (BIBI) scores for several streams in the Portland area. Realistically, the target for control can be set to match the

flows associated with up to 10 percent imperviousness—1.2 cubic feet per second (cfs) for 1-year storm, 2.0 cfs for 2-year storm—shown as the two dotted lines. The target flows for future development would be the "no-net change" rate which would correspond to the zero percent developed grass rate.

The chart also shows the computed control area for SCM as a percent of the subbasin area devoted to control facilities (right y-axis). The solid yellow line relates the need for storm water control area (pond plus access area) to the density of housing or similar planning considerations.

To generate the yellow curve which predicts the land area required to mitigate the increased flow rate (read from the right y-axis), a modeling tool was used to estimate typical stormwater quality and detention facility sizes for different percent impervious area of development. The modeling tool from Clackamas County Water Environment Services is a draft testing version, using a hydromodification stream protection standard, which would be generally more protective than peak flow or flow protection models used in the recent past. The results of this analysis are shown as a percent of the land area required for stormwater facilities. The percent area shown reflects a 10 percent increase in required land area to account for site access and incidental land area around the facility.

For instance, selecting 60 percent impervious on the x-axis matches a value of 6 percent of the subbasin area to be set aside for storm water controls. This was shown to capture the potential land area that may be required for stormwater facilities. DEA's analysis indicates that greater than 6 percent control facility area is necessary when imperviousness is greater than 60 percent. The chart compares this computation to the current CWS LIDA area target of 6 percent of the impervious area (shown as the dotted yellow line on the chart), which would correspond to 6 percent of 60 percent or 3.6 percent. For purposes of planning for SCM, we recommend using the higher figure (meaning following the solid line).

Our findings are general guidelines for concept planning, and represent general approaches to addressing storm water management as a component to the concept plan, and future master plans. Future activities in the SCM effort will incorporate the areas set aside for natural resource protection, including riparian corridors. While these cannot be used as storm water treatment, on a subbasin basis, preserving vegetated areas helps to achieve the stream health target—15 to 25 percent grass and 65 to 75 percent forest. Other considerations in laying out storm water controls include use of off-line facilities, i.e., stream channels themselves cannot be modified to form detention facilities. For purposes of this analysis, there is no difference in the requirement for set aside area for storm water control between site scale and regional scale.

CWS suggests there can be some tailoring of approaches for the respective streams being impacted. Some areas might require additional levels of control due to current condition of the receiving stream. Some facilities would be installed by the developer as part of the required general level of control; if additional control seems to be required, the jurisdiction might need to implement.

Ownership and maintenance of storm water facilities is changing in CWS. The preferred approach is for controls to be installed by developers as part of a new development but for CWS to be granted an access easement; CWS would then maintain.

Attachments:

South Cooper Mountain Existing Storm Conveyance and Treatment Map
South Cooper Mountain Storm Water Connections – NCM Map
South Cooper Mountain Storm Water Connections – SCMAA Map
Impact of Increasing Imperviousness Chart

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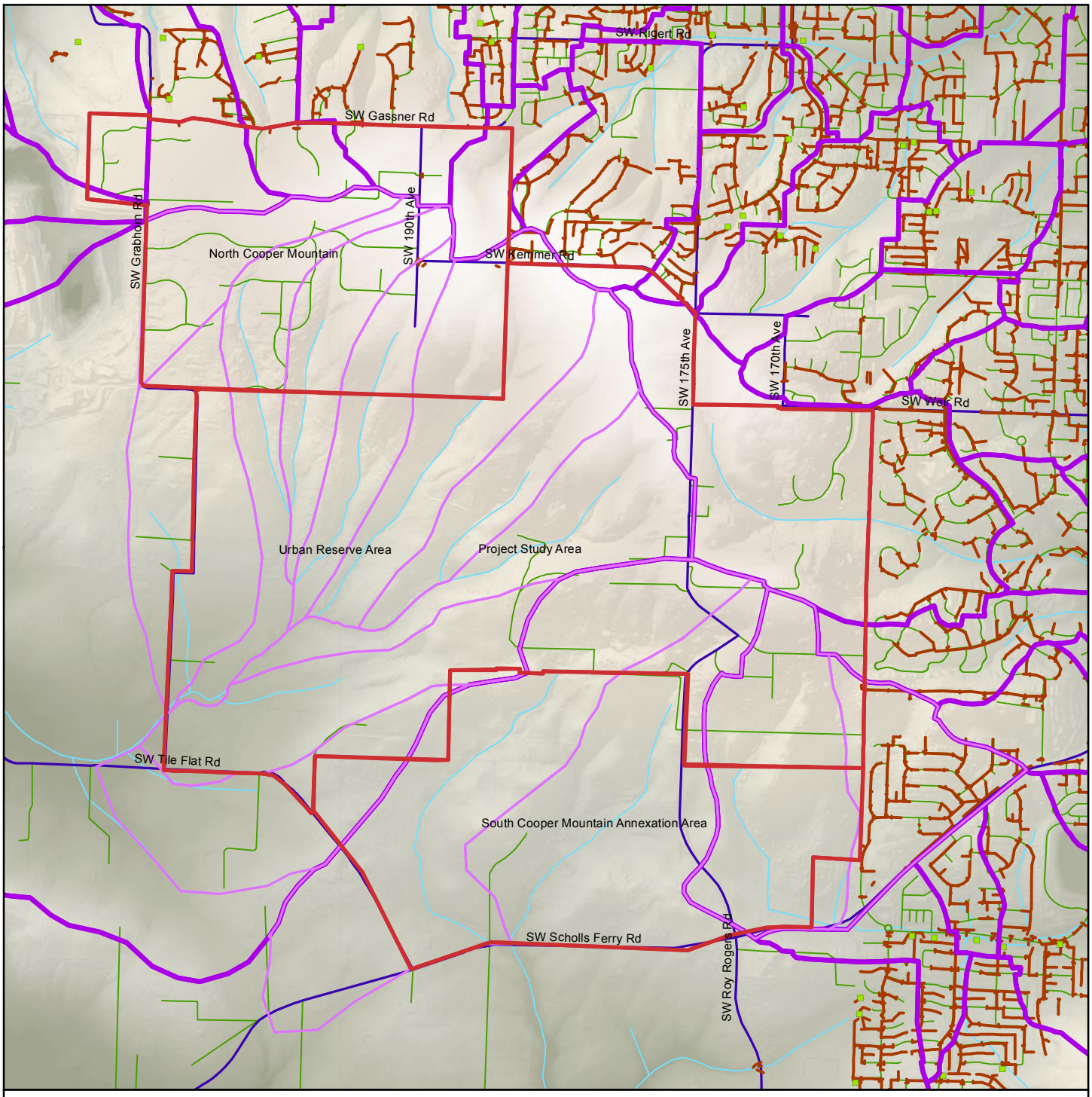


South Cooper Mountain Existing Storm Conveyance and Treatment

Legend

- Gravity Storm Sewers
- Storm Ponds
- SCM Arterials
- streets
- Streams
- SCM Subbasins
- CWS Subbasins
- South Cooper Mountain Study Area

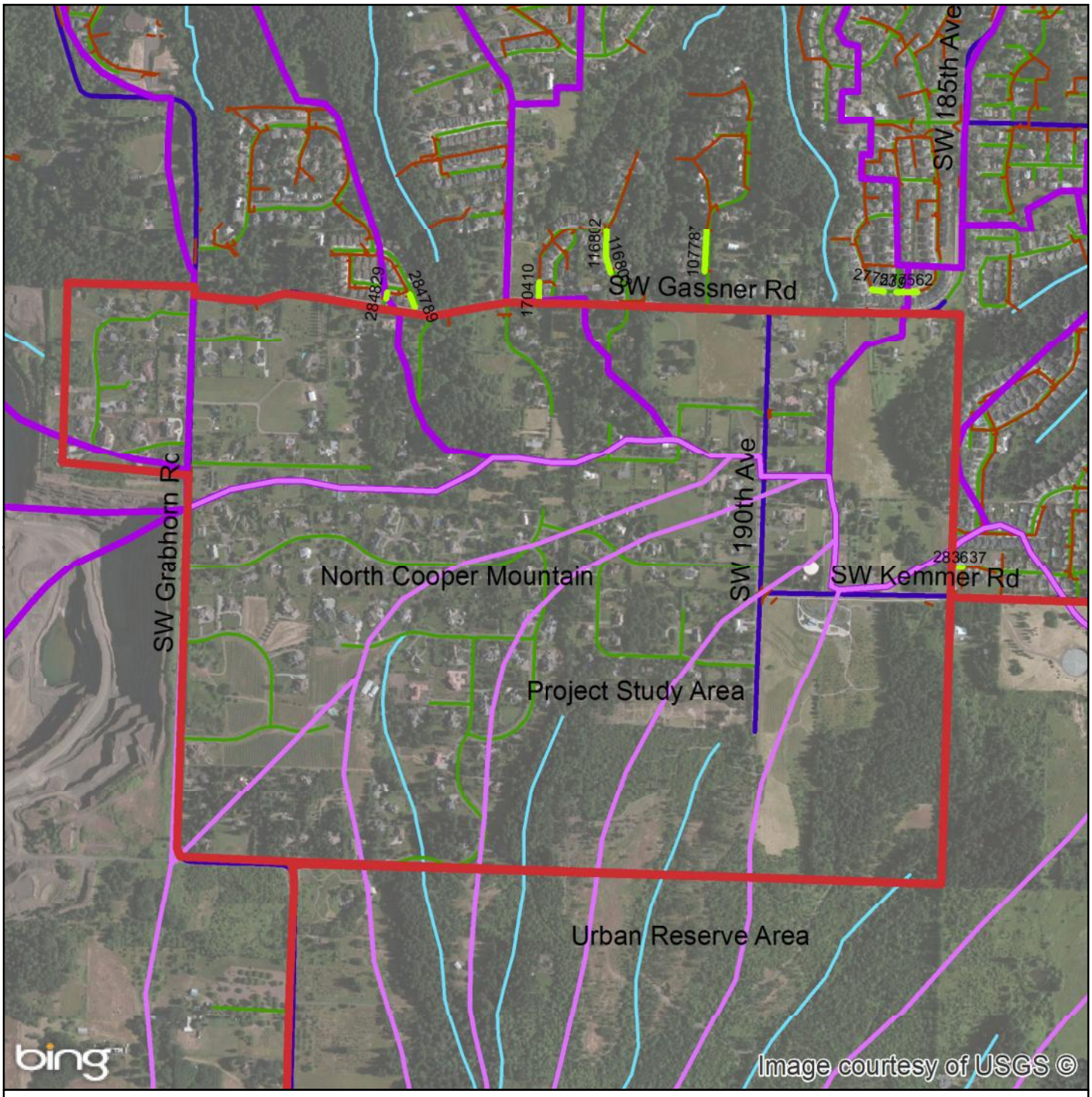
Prepared By: David Evans and Associates

Date: 4/16/2013

Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

NORTH

0 1,000 2,000 4,000 Feet



South Cooper Mountain Storm Water Connections--NCM

Legend

- Storm Water Connections
- Gravity Storm Sewers
- SCM Arterials
- Streets
- Streams
- SCM Subbasins
- CWS Subbasins
- South Cooper Mountain Study Area

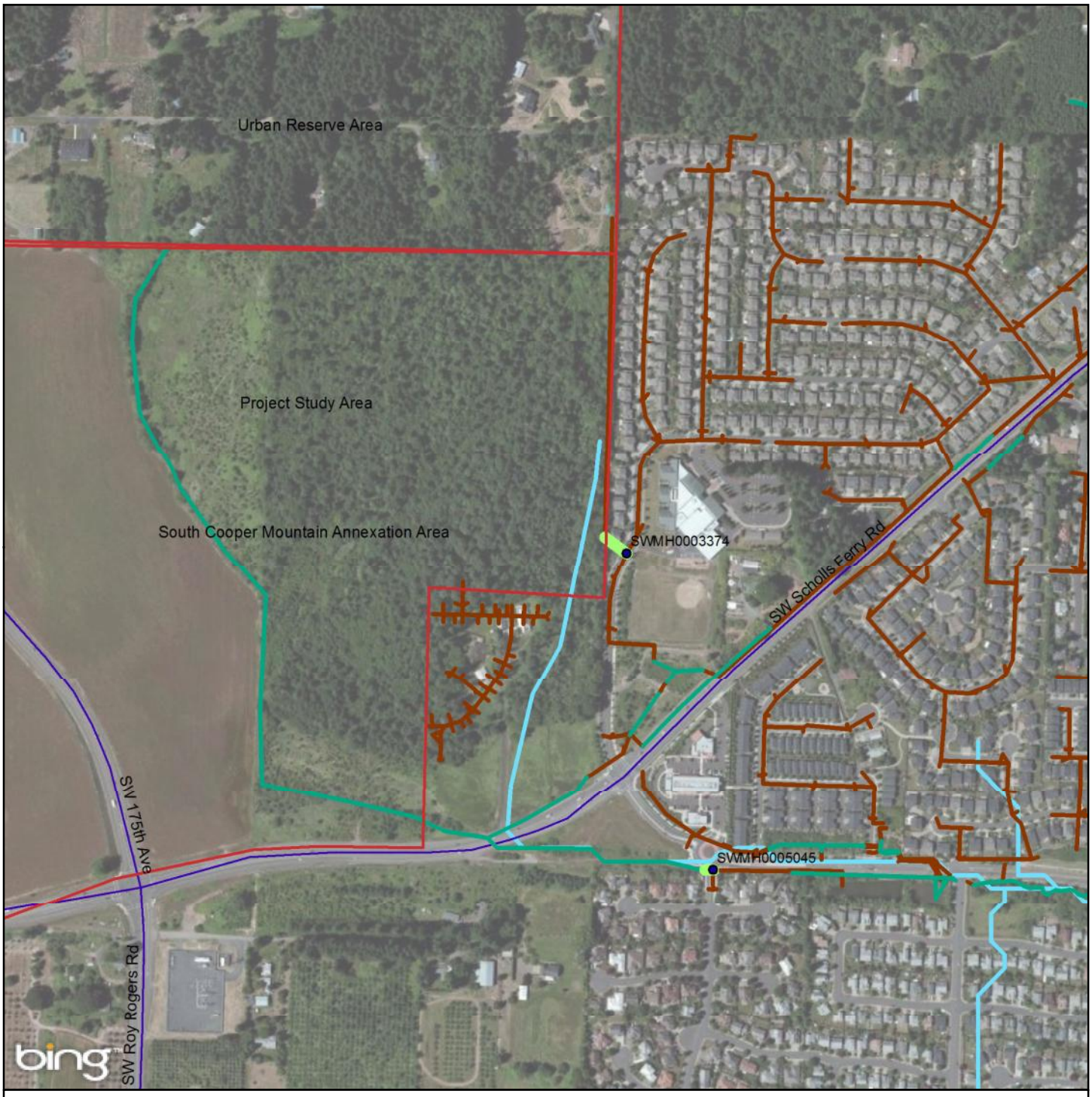
Prepared By: David Evans and Associates

Date: 4/16/2013

Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

NORTH

0 500 1,000 2,000 Feet



South Cooper Mountain Storm Water Connections--SCMAA

Legend

- Storm Water Connection MH
- Storm Water Connections
- COB Open Drain
- COB Gravity Main
- Streams
- SCM Arterials
- South Cooper Mountain Study Area

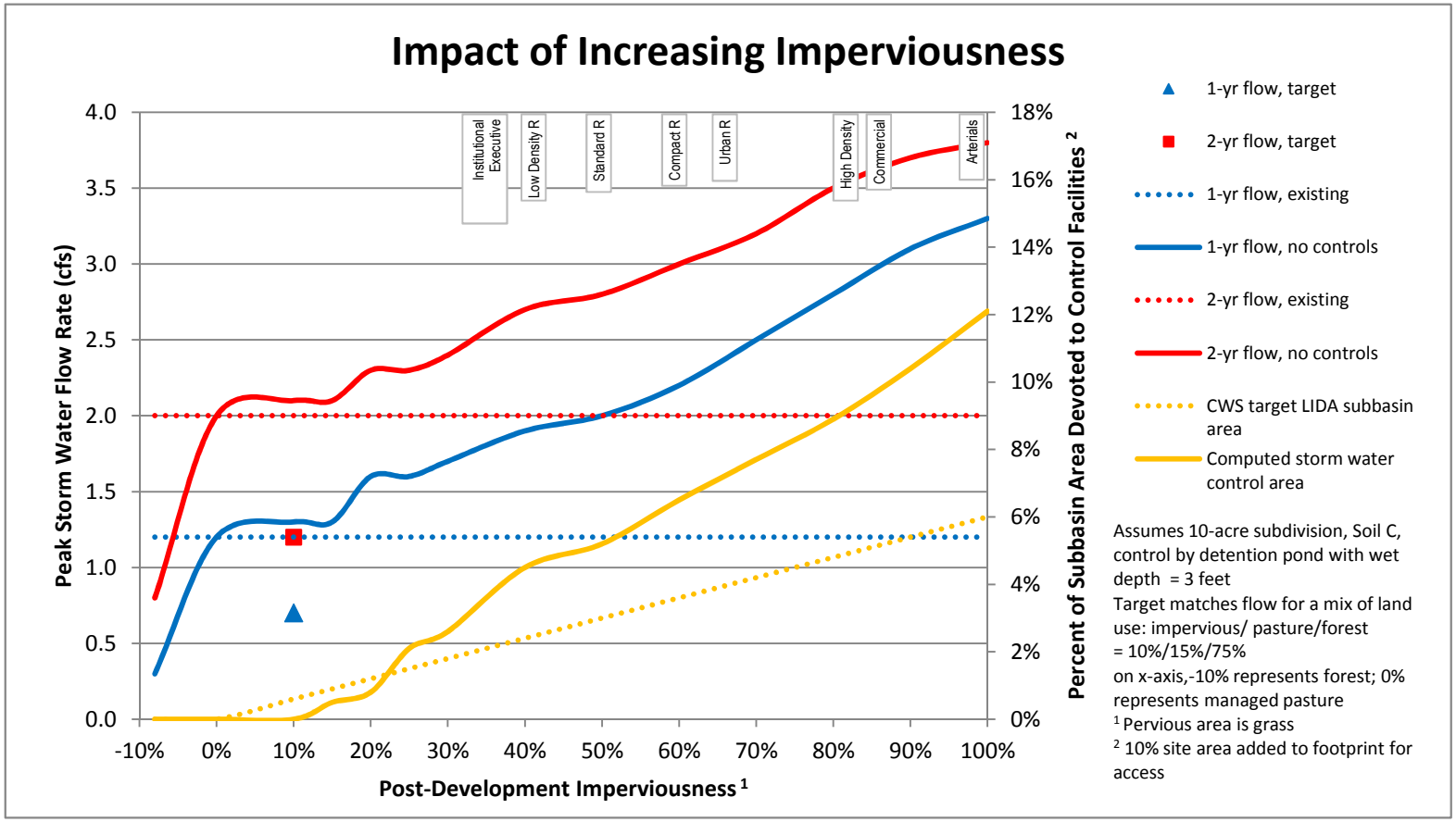
Prepared By: David Evans and Associates

Date: 4/16/2013

Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

NORTH

0 125 250 500 750 1,000 Feet


Impact of Increasing Imperviousness
Peak Storm Water Flow Rate (cfs)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Institutional Executive
Low Density R
Standard R
Compact R
Urban R
High Density
Commercial
Arterials
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Percent of Subbasin Area Devoted to Control Facilities 2
-10%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Post-Development Imperviousness 1
1-yr flow, target
2-yr flow, target
1-yr flow, existing
1-yr flow, no controls
2-yr flow, existing
2-yr flow, no controls
CWS target LIDA subbasin area
Computed storm water control area
Assumes 10-acre subdivision, Soil C, control by detention pond with wet depth = 3 feet
Target matches flow for a mix of land use: impervious/ pasture/forest = 10%/15%/75%
on x-axis,-10% represents forest; 0% represents managed pasture
1 Pervious area is grass
2 10% site area added to footprint for access